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Psychometric evaluation of the medication adherence report scale in caregivers of low-income, urban, African American children with poorly controlled asthma

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ABSTRACT

Objective: Accurately assessing asthma medication usage among low-income, urban, African American children is essential to reduce asthma health disparities. The purpose of this study was to examine the factor structure of the five-item Medication Adherence Report Scale (MARS), in a sample of caregivers of low-income, urban, African American youth with poorly controlled asthma.

Method: Using baseline data from a randomized clinical trial evaluating the efficacy of an environmental control educational intervention, confirmatory factor analysis (CFA) was conducted to ascertain the MARS factor structure. Construct validity was assessed using a regression model inclusive of caregiver-reported medication adherence, Asthma Medication Ratio (AMR), asthma control, and caregiver perception of asthma control as predictors of the MARS.

Results: Caregivers were female (97%) and 27.4% had an annual income under \$10,000. The mean MARS score was 21.88 ± 3.33 out of a possible range of 5–25, representing high adherence. Confirmatory factor analysis indicated that a five-item one-factor model marginally fit the data based on the fit indices: $\chi^2(5) = 31.71$, $p < 0.001$; RMSEA ≤ 0.161 ; CFI = 0.986; TLI = 0.971; and WRMR = 0.979. The MARS was associated with another caregiver-reported measure of medication adherence but not associated with AMR, asthma control, or caregiver perception of asthma control.

Conclusions: The MARS demonstrated marginal fit in CFA and may not be clinically indicated in light of the lack of associations with objective measures of asthma medication adherence and asthma control.

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Introduction

Asthma is one of the most common child health conditions, affecting 8.4% of all youth under the age of 18 years in the United States (1). Low-income, urban, African American children experience disproportionately higher asthma prevalence and morbidity. Nearly 13% of African American children have asthma, compared to 7.7% of non-Hispanic, white children (1). Almost two-thirds of African American children with asthma have uncontrolled asthma compared to 45% of non-Hispanic, white children (2). Asthma-related emergency health care utilization rates (e.g. Emergency Department [ED] visits) and the asthma-related death rate are also higher among African American youth with asthma than their non-Hispanic, white peers with

asthma (3,4). Medication adherence, part of the broader concept of treatment adherence, is an important asthma self-management behavior that is associated with greater asthma control and decreased asthma morbidity (5).

Treatment adherence is defined as “the extent to which a person’s behavior coincides with medical or health advice” (6) (p. 475). Medication adherence, which involves taking medications as prescribed by one’s health care provider, is critical to the management and control of asthma (5,7). Daily use of long-term controller medications is a key component of asthma medication adherence and asthma control (5,7). Among young children with asthma, caregivers bear the responsibility for disease management,

including the administration of daily controller medication (5). However, medication adherence is generally inconsistent among low-income, racial minority children with persistent asthma, with some studies documenting daily-controller medication adherence rates as low as 20% (5,8–10). Risk factors for suboptimal or inconsistent medication adherence among low-income, urban, African American children with asthma are multi-level and include lack of access to specialty care (11), neighborhood crime (12), difficulty establishing family asthma management routines (i.e. refilling medications on time, making medications visible, having a set time to take them, and reminding the child to take them) (13–15), parent concerns about medications and their side effects (11,15–18), and maternal depressive symptoms (19–21), among others.

Consequently, medication adherence may be a high-yield area to target in clinical and research settings as a means to address health disparities in asthma morbidity among low-income, urban, African American youths with poorly controlled asthma. The Medication Adherence Report Scale (MARS), originally developed by Horne & Weinman (22), is a brief, self-report measure of adherence to medication that has been used across various populations of people with asthma, including low-income, urban, African American children (16,23–27).

The validity of the MARS has been evaluated in a number of studies, but an analysis of its factor structure has not been conducted, and research with low-income African American families has been limited (24–27). Cohen et al. (24) assessed adherence to daily controller medication in a prospective cohort study of 318 urban, predominately racial minority adults with asthma, and found that the 10-item MARS-Asthma had good internal reliability ($\alpha = 0.85$) and was significantly correlated with electronically measured adherence (metered-dose inhaler). Koster et al. (27) evaluated a five-item version of the MARS in a sample of Dutch adolescents between the ages of 12 and 18 years with asthma and likewise observed good adherence on the MARS-5 (i.e. a score ≥ 23) to be significantly associated with well-controlled asthma. In contrast, Garcia-Marcos et al. (25) concluded that caregiver-reported adherence using the five-item MARS was “too inaccurate” (p. 1089) to be useful in research or clinical practice in their year-long prospective cohort study of controller medication adherence in children with persistent asthma between the ages of two and 13 years. Finally, Jochmann et al. (26) compared the MARS to adherence measured by an electronic monitoring device in a prospective

observational study in a sample of 95 British children with asthma. They also failed to find a significant relationship between scores on the MARS and adherence measured objectively; however, the authors did not specify whether the caregiver or the child was the MARS respondent.

In summary, despite the broad use of the MARS, the psychometric properties of this instrument have not been evaluated among caregivers of low-income, African American children with uncontrolled asthma. The purpose of this study was to investigate the internal reliability, factor structure, and construct validity of the five-item self-report MARS in sample of caregivers of low-income, urban, African American children with uncontrolled asthma in order to determine its appropriateness for use in research and clinical practice with this high-risk population.

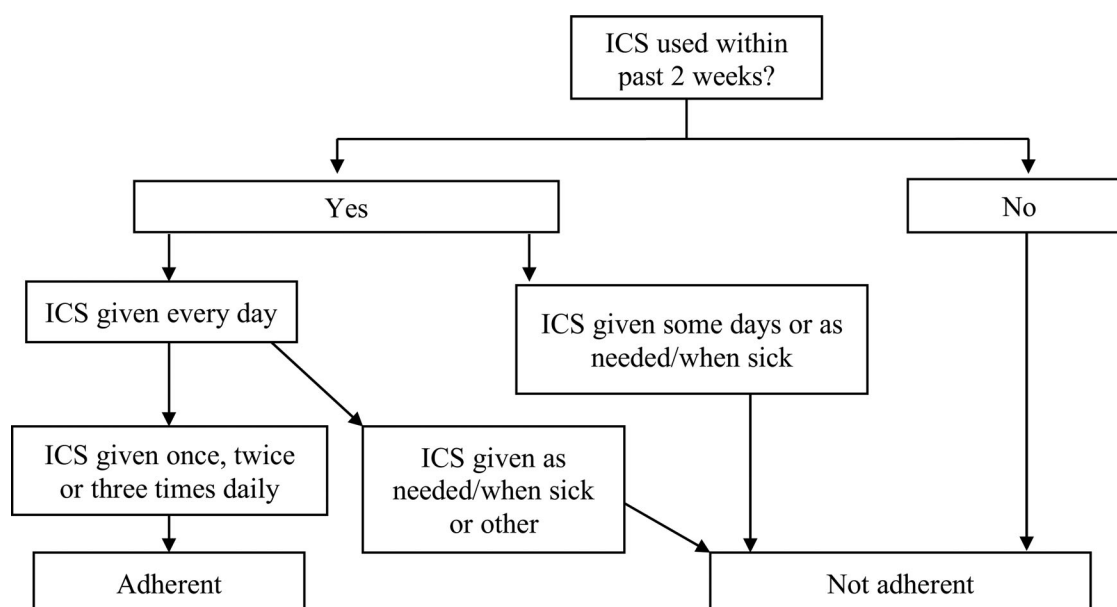
Methods

Data source

We used baseline data from a randomized controlled trial (RCT) that evaluated the efficacy of the Asthma Express Environmental Control Educational Intervention for children with persistent asthma and frequent emergency department visits (28). Participants were recruited from two large urban hospitals during a pediatric ED visit for treatment of an acute asthma exacerbation. Eligible children (a) were between the ages of three and 12 years; (b) had physician-diagnosed persistent and uncontrolled asthma based on the NAEPP (7) guidelines; (c) had ≥ 2 asthma-related ED visits or ≥ 1 hospitalization for an asthma exacerbation during the previous 12 months; and (d) lived in the Baltimore metropolitan area. Children with significant non-asthma respiratory condition (e.g. cystic fibrosis), who did not have a working phone, or were in foster care were ineligible. Participants were enrolled between August 2013 and February 2016 on a rolling basis. Each caregiver who agreed to participate and met the eligibility criteria completed a survey at baseline with key sociodemographic and health information as well as self-report measures of child asthma medication adherence. The institutional review boards of the associated university medical centers approved the clinical trial. Prior reports detail the trial's data source, data collection, and intervention (28). We restricted our analysis to the 207 African American participants who comprised 93% of the total sample ($N = 222$) of urban children aged three to 12 years with persistent and uncontrolled asthma and their caregivers.

Table 1. MARS item descriptions, frequencies, percentages, and missing data.

MARS Item	Response N (%)			
	Very often (1) or Often (2)	Sometimes (3)	Rarely (4) or Never (5)	Missing
1. I sometimes forget to give my child his/her asthma medicines.	9 (4.3)	50 (24.0)	147 (70.5)	2 (1.0)
2. I sometimes miss out on a dose of their medications.	8 (3.9)	55 (26.4)	143 (68.8)	2 (1.0)
3. I sometimes alter the dose of my child's asthma medications to suit their needs because it seems like they need it.	13 (6.2)	38 (18.3)	154 (74)	3 (1.4)
4. I sometimes stop giving the asthma medication to my child for awhile	11 (5.3)	19 (9.1)	175 (84.2)	3 (1.4)
5. I sometimes give less of the medication to my child than instructed.	5 (2.4)	17 (8.2)	182 (87.5)	4 (1.9)

**Figure 1.** Questions and algorithm comprising caregiver-reported inhaled steroid medication adherence. ICS = inhaled corticosteroid (i.e. controller medication).

Measures

Medication adherence

Koster, Raaijmakers, Vijverberg, & Maitland-van der Zee (29) first utilized a five-item MARS with caregivers of children between the ages of four and 12 years with asthma. This version of the MARS aims to assess the caregiver's account of lapses or changes in administering their child's asthma medication (see Table 1). Scores on the MARS-5 range from five to 25, with higher scores indicating better adherence. Among caregivers of low-income, urban, racial minority children with asthma, a score of ≥ 22 on the MARS-5 indicates "high adherence" (30). The MARS-5 was treated as a continuous variable.

Caregiver-reported inhaled steroid adherence

As shown in Figure 1, caregivers were asked a series of questions regarding their child's use of a daily inhaled steroid (i.e. controller medication) in order to determine whether they were 'Adherent' or 'Not

adherent.' (30). 'Adherent' was entered into the model and 'Not adherent' served as the reference variable.

Asthma medication ratio (AMR)

The AMR was calculated by obtaining pharmacy dispensing records from the past 12 months from pharmacies identified by the caregiver. The AMR is calculated by dividing the number of controller medication fills by the total asthma medication fills (i.e. controller medication and rescue medication), as described by Schatz et al. (31). An $AMR \geq 0.50$ has been associated with decreased asthma morbidity, including better asthma control, less severe asthma symptoms, better quality of life, and fewer hospitalizations and ED visits in adults and children with asthma (31–33). The AMR was used as a continuous variable.

Caregiver perception of asthma control

Caregivers were asked whether they believed that their child's asthma was well controlled in the past four weeks ('Yes,' 'No,' and 'Unsure'). Caregiver perception of asthma control was dummy-coded with 'Yes'

entered into the model and 'No' and 'Unsure' combined into one category and serving as the reference variable.

Asthma control

Asthma control was assessed based on an algorithm from the NAEPP-EPR3 (7) guidelines which incorporates caregiver reported information on the child's asthma days symptoms, night symptoms, activity limitations due to asthma, rescue medication use, ED visits or hospitalizations in the past year, and oral steroid use in the past year (28). Asthma control was dummy-coded with 'Very poorly controlled' entered into the model and 'Not well controlled' serving as the reference category.

Sociodemographic characteristics

Extensive demographic data were collected at baseline about the child and caregiver. Child demographic data included age in years and gender. Caregiver data included age, gender, marital status, employment status, education level, and annual household income. Child asthma severity was determined at baseline according to the NAEPP-EPR3 (7) guidelines and was dummy-coded with 'moderate' and 'severe' entered into the model and 'mild' as the reference group.

Data analysis

Confirmatory Factor Analysis (CFA) was conducted using Mplus, Version 8 (34) to evaluate the factor structure of the MARS and assess its appropriateness in a population of caregivers of low-income, urban, African American children with uncontrolled asthma. Based on Kline's (35) guidelines regarding Likert-scales with five or fewer categories, the mean- and variance-adjusted weighted least squares (WLSMV) estimator for ordered categorical data was utilized. Multiple fit indices were evaluated including: Chi-square Test of Model Fit (χ^2), Root Mean Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), and Tucker-Lewis Index (TLI), and Weighted Root Mean Square Residual (WRMR) (35,36). The following cutoff values were used to define acceptable fit: non-statistically significant χ^2 ($p \geq 0.05$); RMSEA ≤ 0.06 ; CFI ≥ 0.95 ; and TLI ≥ 0.95 ; and WRMR < 1.0 (36,37). Lastly, the significance and magnitude of factor loadings were examined using Kline's (35) benchmark that standardized factor loadings ≥ 0.70 are considered an acceptable indicator that the item adequately represents the underlying construct. The WLSMV estimator in Mplus, version 8 handles missing data using a

model-based imputation method that assumes that data are missing completely at random with respect to x-variables (34).

In order to evaluate the construct validity of the MARS, factor scores for the MARS in Mplus were extracted and a regression analysis was run in SPSS Version 21.0 (38) using the factor scores as the dependent variable and the following variables as predictors: child asthma control, caregiver perception of child asthma control, AMR, and caregiver-reported inhaled steroid adherence. Mplus uses a refined, regression method to create factor scores (39). This method predicts the location of each individual on the factor (i.e. adherence as measured by the MARS) and allows for the incorporation of factor information as part of a regression analysis (39).

Results

Sample characteristics

A majority (65%) of the children in the sample were male, and the mean child age was 6.3 years ($SD = 2.7$ years) (Table 2). Caregivers were primarily female (97%) had a mean age of 31.5 years ($SD = 7.6$). Just over half of the caregivers (55.3%) were employed. Nearly a third (27.4%) of caregivers reported an annual household income that was less than \$10 000. Asthma morbidity was high with almost a third of the children (27.9%) categorized with severe, persistent asthma. Children had an average of nearly six days with asthma symptoms in the past two weeks and an average of seven symptoms nights in the past four weeks. Based on established guidelines (7) over half of the children (55.3%) had asthma that was very poorly controlled (compared to not well controlled). At the same time, 57.7% of caregivers perceived that their child's asthma was controlled in the past four weeks. The AMR could not be calculated for 24 children in the sample because these children did not have any asthma medications on record at any area pharmacy that the caregiver had identified using in the past year. For the remaining 184 children with complete pharmacy records, the mean AMR was 0.43 ($SD = 0.26$) or poor controller medication adherence. Over 50% of the sample had an AMR below 0.50, indicating low controller medication use based on the cutoff (31); however, 56.3% of caregivers reported that their child was adherent with inhaled steroid medication use. Table 2 presents full sample characteristics, asthma morbidity and medication usage data.

Table 2. Participant demographics, asthma morbidity, and medication adherence.

	Mean (SD)
Child's age	6.3 (2.7)
Child male ⁺	136 (65)
Asthma severity ⁺	
Mild, persistent	55 (26.4)
Moderate, persistent	95 (45.7)
Severe, persistent	58 (27.9)
Asthma control ⁺	
Well controlled	0 (0)
Not well controlled	93 (44.7)
Very poorly controlled	115 (55.3)
Caregiver age	31.5 (7.6)
Caregiver female ⁺	202 (97)
Caregiver single ⁺	156 (75)
Caregiver employed ⁺	115 (55.3)
Caregiver HS education or more ⁺	168 (80.8)
Annual household income ⁺	
< \$10,000	57 (27.4)
\$10,000-\$19,000	38 (18.3)
\$20,000-\$29,000	32 (15.4)
\$30,000-\$39,000	23 (11.1)
≥ \$40,000	30 (14.4)
Missing/refused	28 (13.4)
Did parent perceive child's asthma to be controlled in past 4 weeks? ⁺	
Yes	120 (57.7)
No or unsure	88 (42.3)
AMR	0.43 (0.26)
Parent-reported controller medication adherence ⁺	
Adherent	117 (56.3)
Nonadherent	39 (18.8)
MARS	21.88 (3.33)

Note: ⁺N(%). HS = High School. AMR = Asthma Medication Ratio. MARS = Medication Adherence Report Scale.

Data screening

Prior to CFA, item frequencies and missing data for the MARS were examined. Overall, the data indicated high levels of adherence among the participants. As shown in Table 1, most caregivers responded with a four (*Rarely*) or five (*Never*) on each item. In contrast, very few participants selected one (*Very often*) or two (*Often*), yielding several cell sizes of ten or fewer. Missing data were minimal, ranging from 1% to 1.9% per item (Table 1). Given the skewed distribution of the responses, the categories were collapsed and the data recoded into a three-point Likert scale. Response options one (*Very often*) and two (*Often*) were combined as well as four (*Rarely*) and five (*Never*), which yielded the three categories that best approximated a normal distribution.

CFA and construct validity

A five-item one-factor model was tested and assessed using the previously described fit indices. This model demonstrated marginal fit to the data. With the exception of a statistically significant chi-square test and a RMSEA value that was above the ≤ 0.6 cutoff, the fit indices indicated acceptable fit: $\chi^2(5) = 31.71$,

Table 3. Factor loadings for final model.

MARS Item	Unstandardized	Fully standardized
1. I sometimes forget to give my child his/her asthma medicines.	1.000	0.904
2. I sometimes miss out on a dose of their medications.	1.106	1.000
3. I sometimes alter the dose of my child's asthma medications to suit their needs because it seems like they need it.	0.654	0.591
4. I sometimes stop giving the asthma medication to my child for awhile	0.750	0.678
5. I sometimes give less of the medication to my child than instructed.	0.833	0.753

Note: All loadings are significant at $p < 0.001$.

Table 4. Predictors of medication adherence.

Variable	Medication adherence (MARS)	
	B	95% CI
Constant	-0.386*	[-0.722- -0.049]
Very poorly controlled asthma	0.132	[-0.085-0.350]
Parent perceives asthma control	-0.182	[-0.398-0.034]
AMR	0.073	[-0.412-0.558]
Parent-reported controller medication adherent	0.270*	[0.036-0.504]
r ²	0.090	
F	3.326*	

Note: N = 208. CI = confidence interval. AMR = Asthma Medication Ratio. * $p < .05$.

$p < 0.001$; RMSEA ≤ 0.161 ; CFI = 0.986; TLI = 0.971; and WRMR = 0.979. Factor loadings were all statistically significant at $p < 0.001$ and ranged from 0.591 to 1.00 (Table 3). No modification indices > 10 were suggested by Mplus. Cronbach's α was 0.75. As presented in Table 4, the regression analysis indicated that caregivers who reported controller medication adherence had higher scores on the MARS ($B = 0.27$, $p = 0.024$). Level of asthma control, caregiver perception of asthma control, and AMR were not statistically significant predictors of medication adherence measured by the MARS (Table 4).

Discussion

This is the first known study to evaluate the psychometric properties of the MARS in a sample of caregivers of low-income, urban, African American children with uncontrolled asthma. CFA resulted in a one-factor solution that demonstrated marginal fit. Construct validity analysis revealed that the MARS was significantly associated with another caregiver-reported measure of medication adherence (i.e. inhaled steroid medication adherence), but not with AMR, which was based on objective pharmacy data. These results are congruent with a well-developed body of literature indicating that self-reported adherence is inconsistently related to more objective

measures of adherence, such as electronic monitoring or pharmacy data, among adults or children with chronic illness (40). Several studies have examined the relationship between parent-reported adherence (using MARS or other measures) and objective measures of adherence (including AMR) in children with asthma and failed to find a statistically significant relationship (25,26,41).

In addition to a lack of congruence with the AMR, MARS scores were not associated with asthma control, a known outcome of medication adherence (42), or with caregiver perception of the child's asthma control. It is possible caregivers do not fully associate medication adherence and asthma control due to lack of knowledge about how asthma medications work (17) or because they conceptualize adherence and/or asthma control incongruent with the national guidelines. Mansour et al. (18) conducted focus groups with 40 parents of urban, African American children aged five to 12 years (55% had moderate to severe asthma), which revealed that parents did not administer asthma medication as prescribed because they did not equate medication use with prevention of asthma symptoms. In another qualitative analysis, Bokhour et al. (43) examined the relationship between asthma medication adherence and explanatory models of asthma among 37 parents (17 African American) of children aged five to 12 years with persistent asthma. They found that the parents of children who were unintentionally nonadherent (i.e. not taking medication as prescribed and unaware) and intentionally nonadherent (i.e. intentionally not taking controller medication as prescribed and aware) conceptualized the child's asthma as an acute, episodic illness rather than a chronic illness. Although the importance of eliciting parent health beliefs and explanatory models of adherence and control have long been recommended to build a shared clinical reality that may facilitate and enhance parent administration of asthma medications as prescribed (44,45), findings from this study suggest that profound gaps persist.

High risk children were recruited to maximize the ability to detect a difference in asthma outcomes between the intervention and control group (28). Although none of the children in the sample had well controlled asthma according to the national guidelines, 57.7% of mothers reported that they believed their child's asthma to be controlled in the past four weeks. A similar proportion of mothers (56.3%) reported their children were adherent to an inhaled steroid medication, and MARS scores indicated very high levels of adherence ($M = 21.88$). Other studies

have similarly found that parents overestimate both asthma control and controller medication use (15,46). The positive skew of the MARS items further points to caregiver overestimation and misperception of adherence and suggests a ceiling effect that makes it difficult to discern differences between caregivers with high scores. A positive skew has been reported in several other studies that used the MARS among caregivers of children with asthma (23,25,26). Specifically, among low-income, urban, African American children with asthma Butz et al. (23), found that 80% of caregivers had a score above 20 on the MARS.

The discordance between asthma control and caregiver-reported adherence measured by the MARS is consistent with, and further highlights, the known methodological problems with measuring adherence via self-report, including recall bias and social desirability bias (5,47,48). Indeed, recall bias threatens the validity of self-report measures such as the MARS (47). Social desirability has been identified as one of the largest threats to the accuracy of self-report adherence measures and occurs when individuals inflate their level of adherence in order to avoid disappointing their health care provider (40,47,49).

The observed high levels caregiver-reported adherence on the MARS and high child asthma morbidity in this sample perhaps indicate that the caregiver perception of adherence may diverge from how adherence is conceptualized in the national guidelines. The NAEPP-EPR3 (7) guidelines emphasize correct, daily use of long-term controller medications to *prevent* symptoms. Given that the language of the MARS is vague and does not specify asthma medication type (i.e. controller, rescue, or even oral steroid), it is possible that caregivers were reflecting on their child's use of short-acting rescue medication rather than long-term controller medication when responding to the MARS. Previous studies have shown that African American children, particularly those from low-income families, may rely on rescue medication to control their asthma (50,51) and utilize a reactive rather than preventive approach to asthma management (43,46).

The results of this analysis have clinical and research implications. The MARS, especially if used alone, is likely not the best option for assessing medication adherence in research with caregivers of low-income, urban, African American children with uncontrolled asthma. Because each form of adherence measurement (i.e. self-report, electronic monitoring, pharmacy refill data) has advantages and disadvantages, Al-Hassany et al. (47) suggest that a

combination of different methods may provide the most accurate information in a research setting.

In a clinical setting, health care providers need to quickly assess and monitor medication adherence at every visit (7,52). Only a very small proportion of individuals with a chronic health condition—approximately one out of six—achieves near perfect adherence to a medication regimen (48). Having a nonjudgmental conversation with the child and family that (a) normalizes nonadherence, (b) acknowledges the larger social-ecological context within which medication adherence occurs, and (c) addresses other specific barriers to adherence may be more useful than administering the MARS, especially given that studies have documented that even just talking about medication adherence and asking for input from the family can lead to improved adherence (6,53–55). Similarly, pharmacy claims data can be used as a valid and reliable method of targeting outreach to children and youth who are at-risk for poor adherence based on AMR (56).

This study has limitations. Because we used baseline data, we could not evaluate the test re-test reliability of the MARS, nor could we evaluate the stability of the factor structure of the MARS over time. The results of the analysis are specific to low-income, urban, African American children with poorly controlled asthma and their caregivers and may not be generalizable to other populations of children with asthma and their caregivers. Eligibility requirements of the Asthma Express RCT also resulted in an exclusive sample of children with uncontrolled (vs. well controlled) asthma at baseline. Indeed, at baseline, children fell into the categories of “not well controlled” or “very poorly controlled” whereas by 12-months follow-up, some children were categorized as having “well controlled” asthma. It is possible that lack of variance in the measure of asthma control at baseline (i.e. restriction of range) could have contributed to the absence of a significant association with the MARS. Additionally, common method (i.e. parent self-report) bias may explain the statistically significant relationship between the MARS and caregiver-reported inhaled steroid (i.e. controller medication) adherence.

Conclusion

In summary, the results of this study highlight that a five-item one factor MARS demonstrated marginal fit in CFA and may not correspond to objective measures of asthma medication adherence or asthma control as indicated by the regression analysis. Furthermore, the high levels of asthma morbidity among the children in

this sample despite high scores on the MARS reflect the possibility of discordance between parental health beliefs and explanatory models regarding asthma medication adherence and control and the NAEPP-EPR3 (7) national guidelines. Health care providers need to engage in consistent, non-judgmental communication with children and parents about asthma medication, making sure to attend to specific individual, family, community/environmental, health care system, and sociocultural factors that influence medication adherence in this population. By developing a shared understanding of medication adherence, health care providers have the opportunity to facilitate better medication adherence and reduce asthma morbidity among low-income, urban, African American children with asthma.

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Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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